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A +\$2 billion market for modules in EV/HEV: A big opportunity for power electronics

“Power Electronics for Hybrid & Electric Vehicles, Vol. 1: Active components & Vol. 2: Passive components”,

A report from Yole Développement

Lyon, France – Nov. 8, 2011 – Yole Développement announces its reports “Power Electronics for Hybrid & Electric Vehicles”.

Yole Développement’s report is now structured in two Volumes as follows:

- *A newly-organized full market overview section which is common to both volumes.*
- *Volume 1 details active devices: IGBTs, Super Junction MOSFETs, SiC and GaN-based devices, from the system down to the wafers.*
- *Volume 2 details passive devices: resistors, capacitors, connectors, including technologies evolutions and integration trends.*

Yole Développement’s reports describe the supply-chain evolution and the technologies coming in Power Electronics applied to hybrid and electric cars. With these reports, car manufacturers and tier-one, can make the right partnerships with the right companies, and gain a strategic advantage.

“With this market & technology analysis, we provide the full picture and benchmark competitors and partners technical solutions”, explains Brice Le Gouic, Yole Développement.

In 2016, almost 25 million cars manufactured will be electrified, the majority of them being micro-HEV, with a low level of electrification. However, some 5 million will be full HEV, plug-in HEV or EV.

As a consequence, electric vehicles (EV) and hybrid electric vehicles (HEV) will represent the biggest accessible market for power device and system makers. Without getting completely mature, the EV/HEV industry has seen its first steps toward standardization. Electrical configuration shows a preference for parallel and split structures. Following the same logic, DC/DC boost converters and DC/AC inverters architecture for full HEV and EV are adopted. Getting the best switch at the lowest cost is a must. IGBT will continue having a bright future in hybrid and electric cars.

Yole Développement expects the power module market to be near \$5 Billion, most made with IGBT. It is huge and will change the game in power electronics market!

But there are still some uncertainties:

- What about new power semiconductor device adoption?
- Which materials will be preferred?
- What are the consequences on the rest of the powertrain? Cooling? Integration? Connectivity? Passives?
- What are the consequences on the supply chain?

Electrical architectures are chosen but supply chain keeps on changing

The powertrain supply chain is being absorbed by car makers on one side and power device module makers on the other, leaving few free spaces to tier one suppliers. The supply-chain is literally changing. With EV/HEV, the traction's main part becomes the inverter and the motor. Yole Développement will experience great improvements with innovative switches, inverter designs and topology, regenerative braking etc...

Car manufacturers need to keep that added value, and thus they already started covering the value-chain starting from the semiconductor die. Toyota is even deeper in the supply chain with silicon wafer production capability. GM is closer to Delphi, and they still have manufacturing available at Kokomo (US). And Yole Développement cannot forget the Chinese companies. BYD is now producing IGBTs, and many Chinese semiconductor foundries are now able to do the same.

China: market opportunity or competitive threat?

“China will soon have enough experience to enter foreign markets. The companies in an uncertain position are the European ones: Volkswagen, PSA or Daimler do not have such advantages, and may play with their tier-ones (Valeo, Continental, etc...)” says Alexandre Avron, Yole Développement.

This is also an opportunity for new players. Tesla and Coda are one of those who can come and play with the big ones.

In addition, Chinese companies, supported by the Chinese government already benefit from big car brands and electrified transportation platform to first protect the local market from Occidental and Japanese ones and then expand abroad.

New materials for active components are envisioned and will significantly impact packaging & cooling systems

SiC will be part of the game, but not for today. It will bring high efficiency at even higher cost! Yole Développement expects to reach 41.3M\$ market, a drop in the bucket but a huge potential (39% CAGR 15-20). GaN will struggle at lower power, being the high-end part of micro and mild hybrid. The technology will face advanced Silicon devices such as super junction MOSFETs. However, the future of compound semiconductor in power electronics depends on new developments, and a sudden breakthrough can easily make

any existing roadmap obsolete.

Another point of interest observed in all power electronics domains concerns packaging and module assembly. It is even more important for EV/HEV. Indeed, EV/HEV makers will gain market shares thanks to proprietary innovations, and IP, applicable to a full range of cars.

Toyota started field testing flip-chip modules with double sided cooling in 2008 but in 2010 they went back to classical assembly (DBC one side cooling) and small touch of improvements (Al ribbon bonding and direct cooling). All other players are working hard: Delphi with its Viper module and Mitsubishi developing IPMs.

There will be amazing things done in power module packaging for EV/HEV in the next 10 years, it is only a beginning. Yole Développement expects efforts to develop and release technologies that will quickly and readily transfer to and between other energy conversion markets (PV, Wind, etc.).

Passive components are playing a more and more active role

Passive components used to be the hidden part of power conversion. They are now under spotlights and it is deserved: they represent nearly a quarter of an inverter cost. Better efficiency, signal quality, lifetime, even silence is part of what they can bring. Today's hot topic is capacitor, but Yole Développement extended its research to resistor, connectors as well as power distribution (busbars) to draw the complete picture of EV/HEV inverter market.

Capacitors are becoming application specific, and design and engineering for EV/HEV is very active, starting with form factor. Film capacitor market, used in DC link, are representing 95M\$ in 2011, and expected to grow of 48% each year in average. The film capacitor market is hot due to shortage. Film producers cannot produce in enough quantity. EDLC (Electric double layer capacitor) is the other hot topic. Batteries have their place in EV/HEV for long term energy storage, but when the storage/usage cycle is very short, the so called supercapacitor are more of interest. They are already placed in micro hybrid systems and may enter the EV market for regenerative braking at traffic lights. The re-use of energy would then become even more efficient. EDLC CAGR is to reach 44% for the 2010-2020 period and there are plenty of opportunities to catch.

Connectors market is also of interest. They will represent more than 8 Billion \$ in 2020, including charging systems and peripherals. This huge market is not standardized yet, and thus, each manufacturer is able to bring its added value from an IP. However, several threats are onto connectors market. Others connectors makers for PV market or signal can penetrate. Competition will be very strong on a market widely driven by cost. In parallel with connectors, Yole Développement observes the evolution of internal power connections. Between power PCB, laminated busbars and molded busbars there is a choice to be made regarding the inverter architecture and the electrical needs. We see specific

developments coming, as Rogers Corp. who has a solderable busbar especially for hybrid cars.

Resistor market is a bit apart from the others, quiet and without much innovation. The opportunities may be on integration: capacitor, busbars and resistors all together may represent a high added value

About Power Electronics for Hybrid & Electric Vehicles reports:

- **Authors :**

Alexandre Avron is a full time analyst in power electronics at Yole Développement. He was granted a Master degree in Electrical engineering, with a major in power electronics and microelectronics processes, from Applied Sciences National Institute (INSA) of Lyon, France.

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- **Catalogue price:**

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Power Electronic for EV/HEV report, Passive Components - Volume 2: Euros 3,990.00

Power Electronic for EV/HEV Bundle of 2 reports: Euros 5,490.00

For special offers and the price in dollars, please contact David Jourdan (jourdan@yole.fr or +33 472 83 01 90).

- **Companies cited in these reports:**

ABB, AEG, Amphenol, Audi, AVX, Batscap, Beigi Foton Motor, BMW, Bosch, BYD, Changan Automobile, Chery Automobile, Chrysler, Citroen, Coda, Continental, Cornell Dubilier, CREE, Danfoss, Delphi, Denso, Dongfeng Motors, Eaco, Eldre, Electronic Concepts, Epcos, Faw, FCI, Ford, Fuji Electric, Geely International, GM, Great Wall Motors, Honda, Huanghai Automobile, Hyundai, Idealec, Infineon, International Rectifier, JCI Saft, Kemet, LG Chemical, Magna, Magnetti, Maxwell, Mercedes, Methode, Mitsubishi Electric, NEC, Nichicon, Nissan, Panasonic, Peugeot, Powdec, Renault, Rogers, Rubycon, SAIC, Samwha, Sanyo Electric, Seika Electronic Co. Ltd, Semikron, Semisouth, Shizuki, Taiyo Yuden, TE Connectivity, Tianjin Qingyuan Electric Vehicle, Toshiba, Toyota, Transphorm, Tyco Electronics, Valeo, Volkswagen, Volvo, Wanxiang Electric Vehicle, Wima, Yazaki, Zotye Automobile...

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Beginning in 1998 with Yole Développement, we have grown to become a group of companies providing market research, technology analysis, strategy consulting, media in addition to finance services. With a solid focus on emerging applications using silicon and/or micro manufacturing Yole Développement group has expanded to include more than 40 associates worldwide covering MEMS, Microfluidics & Medical, Advanced

Packaging, Compound Semiconductors, Power Electronics, LED, and Photovoltaic. The group supports companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to develop their business.

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